than begun the scientific investigation of a field which offers the widest opportunities for results. Not only does it seem probable that practically new lines of business are to be created by botany, but the improvement in old methods which have been maintained for centuries simply because 'our fathers' did that way, has already demonstrated to the most conservative that the scientific botanist, true to type, is a man of immense practical value to the farmer, the manufacturer, the engineer and the world at large.

May we none of us, by our work or our words, retard the rapid advance now being made, along both pure and practical scientific lines, of our chosen science—botany.

GEORGE T. MOORE.

BUREAU OF PLANT INDUSTRY.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. SECTION B, PHYSICS.

THE annual meeting of Section B, Physics, of the American Association for the Advancement of Science, in affiliation with the American Physical Society, was held in Philadelphia on December 28, 29 and 30, 1904. The attendance was representative in an unusual degree of the physicists of the entire country, including not only those from many important institutions of the east, but also from the south, the west, and from California. The average attendance was nearly one hundred.

The retiring vice-president, Edwin H. Hall, introduced the presiding officer, Professor W. F. Magie, of Princeton University, the vice-president of Section B. The other officers of the section who were in attendance were Dayton C. Miller, secretary; Henry Crew, councillor; A. W. Goodspeed, member of the general committee; and the following members of the sectional committee, W. F. Magie, E. H. Hall, D. C. Miller, E. L. Nichols, F. E. Nipher, G. F. Hull, A. G. Webster, D. B. Brace.

For the next meeting, to be held in New Orleans, beginning December 29, 1905, the presiding vice-president is Professor Henry Crew, of Northwestern University. The other officers for the New Orleans meeting, so far as now determined, are:

Retiring Vice-President—W. F. Magie.

Members of the Sectional Committee—Henry Crew, W. F. Magie, D. C. Miller, E. L. Nichols, F. E. Nipher, G. F. Hull and A. G. Webster.

Secretary—Dayton C. Miller, Case School of Applied Science, Cleveland, Ohio.

On Thursday the retiring vice-president, Professor E. H. Hall, of Harvard University, gave an address on 'A Tentative Theory of Thermoelectric Action.' This important paper, which is printed in full otherwhere in this journal, was listened to by an unusually large audience.

Twenty-two papers were read before Section B, all of which were of such importance that it was generally expressed that this meeting was one of the most valuable that Section B has ever enjoyed. The subjects may be classified as follows: on light, nine papers; on electricity, five; on meteorology, two; and on general subjects, six papers. Papers on related subjects were grouped together more than had been usual before, and ample time was allowed for discussion. This arrangement added to the value, as well as to the enjoyment, of the sessions.

Beginning on Friday, December 30, the sessions were in charge of the American Physical Society; a large number of valuable papers were read, an account of which is given in the report of the Physical Society.

The abstracts of the papers read before Section B are given below.

Note on the Mirror-Telescope-Scale Method: GEORGE F. STRADLING, Manual Training School, Philadelphia.

Let a ray of light of fixed direction fall upon a mirror turning about a vertical axis. The reflected ray is received upon a plane. If the incident ray passes through the vertical axis, and this axis lies in the plane of the mirror, and the plane on which the reflected ray falls is parallel to the mirror-plane, the curve traced by the spot of light as the mirror turns is a hyperbola. Discussion of another case.

Some Convenient Laboratory Apparatus: Horace C. Richards, University of Pennsylvania.

I. *An Apparatus for Quickly Washing and Filling Vessels with Small Openings.*—It consists of a small glass cylinder mounted on a suitable stand and provided with three outlets, one leading to the vessel which is to be filled, one to that containing the liquid, and the third to an aspirator through a trap. The liquid is first drawn up into the cylinder and then, by intermittent working of the aspirator, is driven into the vessel. A similar process empties the vessel and carries the liquid over into the trap. For mercury, etc., the form is slightly modified so as to prevent loss of the liquid.

II. *A Simple Automatic Mercury Washer.*—Mercury is raised by an aspirator into a vessel placed above a vertical tube filled with dilute nitric acid. When the vessel is filled, the aspirator is automatically shut off and at the same time air is admitted by a pair of valves operated by a float. The mercury then filters through a small valve in the bottom of the vessel and falls in small drops through the column of acid. It is then returned to the reservoir from which it was drawn and so is passed around through the acid as often as is desired, the aspirator being set in action again when the upper vessel is nearly empty.

The Double Suspension Pendulum for Determining the Absolute Value of the Acceleration of Gravity: R. S. Woodward, Carnegie Institution.

This paper describes an apparatus specially designed to avoid the difficulties presented by knife-edge pendulums and to secure a degree of precision in absolute measures of the acceleration gravity comparable with the precision already attained in relative measures.

Heat Insulation of Observatory Domes, Laboratories and Other Buildings. David Todd, Amherst College.

To prevent excessive heat accumulation in the new observatory domes at Amherst waste granulated cork is put in between the interior galvanized iron sheathing and the exterior wood boarding on which the copper roof is fastened. One and one half to two inches of cork is sufficient to keep interior iron always cool to the touch, no matter how hot the copper gets when the sun is shining normally upon it. Mineral wool would be nearer fire-proof and equally good insulation, but adds more weight. Numerical tests will be submitted.

The Relation Between Air Pressure and Velocity. Francis E. Nipher, Washington University. To be published in the *Transactions* of the Academy of Science of St. Louis.

The paper describes a method of determining the constant in the equation $P = kv^2$ when the air blows into the open end of a tube collector. The tube was bolted to a small pulley on a shaft which could be run at various speeds. The open end was 36 inches from the center of the pulley, and the plane of the opening could be set at any angle with the circular path which it describes. When at right angles to the path the air within the tube is found to be in equilibrium during rotation. The

pressure required to balance the outward radial tendency is equal to the pressure due to the wind at the open end of the tube. When this condition is imposed in the equation the value of k is obtained in terms of temperature, barometric pressure and velocity. The value is practically independent of v for velocities less than 100 miles per hour.

The Temperature and Drift of the Air at Great Heights above the American Continent, Obtained by Means of Registration Balloons. (Preliminary Report.) A. LAWRENCE ROTCH, Director of Blue Hill Meteorological Observatory.

Although the meteorological conditions of the lower two or three miles of air have been investigated by means of kites at Blue Hill Observatory during the past ten years, no observations have been made at greater heights in this country. Through cooperation with the management of the St. Louis Exposition, the author obtained such observations by means of ballons-sondes; fourteen of these balloons carrying self-recording instruments were despatched from St. Louis and all were recovered with ten records of barometric pressure and air temperature. From the barometric records the maximum height attained was found to be about 51,000 feet, where the temperature was 68° F. below zero on September 23. At a height of about 45,500 feet (the maximum of the second series of experiments) the temperature was —72° F. on December 2, the lowest temperature, —76°, occurring at a height of about 33,000 feet on November 26. The direction and velocity of the upper air currents were indicated approximately by the places and times at which the balloons fell. The velocity twice exceeded 100 miles an hour and all the balloons (excepting one which did not rise out of the surface current) drifted towards the east, in general diverging from the areas of low barometric pressure at the ground.

An account of these experiments will be published in full in the *Annals of the Harvard College Observatory,* Vol. LVIII., Part II.

Optical Refraction in the Lower Atmospheric Strata, as Affected by the Meteorological Conditions. (Preliminary Report.) A. LAWRENCE ROTCH, Director of Blue Hill Meteorological Observatory.

The variation in refraction has generally been attributed to the differences in the temperature of superposed strata of air, but there have been few investigations upon the effect of the daily changes in meteorological conditions. Accordingly, during two years, observations were made three times a day with a precise level, on the summit of Blue Hill, of the apparent angular depression of a lighthouse in Boston harbor, fourteen miles distant and 550 feet below the hill, the temperatures here and over the water being known. Since the temperature of the air over the ocean is more uniform than that over the land, there is a large annual period in their difference, but no relation between these vertical gradients and the observed refraction is evident, nor do the monthly extremes appear to be connected with the corresponding gradients of temperature. This indicates that there are other controlling influences and these are now being sought. The investigation will be published in Vol. LVIII., Part II., of the *Annals of Harvard College Observatory.*

Experimental Study of the Use of Weston Instruments for Ballistic Magnetic Testing. ALBERT F. GANZ, Stevens Institute of Technology.

At various times it has been either claimed or disputed that a damped galvanometer in which the damping force is

proportional to the velocity of the moving system may be used for ballistic magnetic testing. In the *Physical Review*, of March, 1903, there is an article by O. M. Stewart in which it is shown mathematically that such a damped galvanometer conforms to the ordinary law of the undamped ballistic galvanometer. It is also stated in this article that an ordinary Weston ammeter without its shunt or a Weston voltmeter without its series resistance may be used for determining permeability and hysteresis curves by the ballistic method.

The experiments to be described in this paper were undertaken last spring by two senior students, Mr. E. E. Greve and Mr. A. R. Barkus, under the direction of the writer, for the purpose of comparing the permeability and hysteresis curves obtained by means of ordinary Weston instruments, with the curves obtained by means of a slow-period undamped ballistic galvanometer. It was found that the curves for a laminated iron ring obtained with an ordinary Weston instrument fell about three per cent. below the curve obtained with the ballistic galvanometer. It was also found that the permeability curve for a solid iron ring (cross-section 1 sq. in. mean diam. 7 in.) obtained with an ordinary Weston instrument fell over ten per cent. below the curve obtained with the ballistic galvanometer. The cause of this falling below is undoubtedly that the time of the first swing of the ordinary Weston instrument is too short to take account of all the change in the magnetic flux which occurs. The Weston Instrument Co. then constructed a special instrument having a greater moment of inertia and more magnetic damping than their ordinary instruments, and having, therefore, also a much longer time for its first swing. This new instrument was found to give a permeability curve for the laminated ring which agreed exactly with the curve obtained with the ballistic galvanometer. For the solid ring the permeability curve was still, however, several per cent. below the curve obtained with the ballistic galvanometer. In order to make a direct reading magnetic flux meter out of this instrument ten yards of flexible cord were taken to be used for a secondary coil, and a resistance was added to the instrument, and this was adjusted so that the instrument would indicate the flux in kilomaxwells changed per turn using this secondary. This instrument was, therefore, called a 'Weston Maxwell meter.' This Maxwell meter has been considerably used in the laboratory of Stevens Institute for obtaining magnetization curves, measuring leakage coefficients, etc., and has been found extremely useful. The Weston Co. are now constructing a second special instrument having a still slower period, which is expected to give accurate results as well for solid iron samples as for laminated ones, and this will be a direct reading, portable and permanent Maxwell meter having a uniform scale, which will be generally useful for all kinds of magnetic testing and which can be used directly without previous calibration. Owing to the slow period of these special instruments the extent of their first throws can be very accurately noted.

Measurement of the Thompson Thermo-electric Effect in Iron. Edwin H. Hall, Harvard University.

Description and Demonstration of the Poulsen Telegraphone. Z. B. Babbitt, New York; Introduced by Arthur W. Goodspeed.

The principles involved in the Poulsen telegraphone and the practical construction of the apparatus were explained. The reproduction of human speech was then demonstrated.

Circular Dichroism in Natural Rotary Solutions. D. B. BRACE and W. P. MCDOWELL, University of Nebraska.

Electric Double Refraction in Liquids Under Low Electric Stresses, and also at the Boiling Point. D. B. BRACE, G. W. ELMEN and L. B. MORSE, University of Nebraska.

The Electromagnetic Theory and the Velocity of Light. HENRY T. EDDY, University of Minnesota. (To be published in the *Physical Review.*)

Mr. Mills has recently published a paper* in which he has given the results of measurements made by him of the increase in the velocity of circularly polarized light in bisulphide of carbon along the lines of force in a magnetic field. Employing circularly polarized light, he was successful in obtaining a difference of one or more wave-lengths between two rays circularly polarized in opposite senses, one ray having its velocity increased while the other was decreased, and this was obtained with apparatus with which no difference whatever was observable in case of plain polarized rays.

The apparatus mentioned is a form of interferometer devised by Professor Morley and paid for by a grant made by the American Association for the Advancement of Science for the purpose of investigating certain points to which the present writer had taken exception in the theory of the Faraday effect as developed by Professor Rowland,† who had attempted to account for the twisting of the plane of polarization of plane polarized light while being propagated along the lines of force in a magnetically active medium by the action of the Hall effect in the medium. As just stated, the present writer found himself unable to agree with that part of Professor Rowland's most valuable theoretical treatment of the Hall effect which related to rotary polarization. After a full presentation of the theoretical questions involved at the Toronto meeting of the American Association for the Advancement of Science, in 1889, the apparatus was constructed, and after many delays a final report was presented to the American Association for the Advancement of Science, at the Boston meeting, August, 1898. The report was duly published* and contains, first, the present writer's theoretical developments and computations as to the possible increase or decrease in velocity to be looked for in case of magnetic twisting of the plane of polarization, and second, a full description by Professor Morley of his apparatus and a detailed account of the experimental work by Professors Morley and Miller, who worked in collaboration. No experimental change in the velocity of plane polarized light could be detected with this apparatus, and the numerical computations just mentioned showed in fact the possible change in the velocity to be too minute to be detected by the apparatus as used. Although such is the fact with plane polarized light, the experiments of Mr. Mills show that such is not the fact with circularly polarized light. Moreover, it will be shown theoretically that in case of circularly polarized light the amount of change in velocity due to the magnetic field is expressible as a lower power of small quantities, than in case of plane polarized light, and consequently the magnitude of the change in the former case is large compared with the latter, and in fact varies as the square of the latter; and while the latter may be quite beyond the range of observation, the former may be well within it, as the experiments of Mr. Mills have proven.

In view of this it is the aim of this paper

* *Phys. Rev.*, Vol. XVIII., p. 65, Feb., 1904.

† *Am. Jour. Math.*, Vol. 3, p. 109, 1880.

* *Phys. Rev.*, Vol. VII., p. 282, December, 1898.

in the first place to rediscuss the questions at issue and point out more in detail than heretofore how, according to elementary theory, the velocities of plane and circularly polarized rays in any optically or magnetically active medium must be necessarily related to each other, and how, according to elementary theory, it is impossible that Professor Rowland's equations can represent a twisted plane polarized ray.

In the second place, it will be shown how these velocities in the magnetically active field are related to the velocity in zero field according to the several proposed hypotheses. Were it possible to make this comparison experimentally, we should have a test as to the validity of the proposed hypotheses, but such test is as yet beyond reach by reason of the smallness of their differences.

An attempt is made, in the third place, to show that a moderate degree of absorption would exert a negligible influence in modifying the results already developed for perfectly transparent media.

The conclusions arrived at in this paper may be briefly stated as follows:

1. The increase or decrease in the velocity of circularly polarized light observed by Mr. Mills, and previously by Professor Brace, are perfectly in accord with and a necessary consequence of the elementary trigonometrical equations expressing the propagation of twisted plane polarized light, and the phenomenon is independent of any hypothesis, electromagnetic or otherwise, as to the manner in which the twisting is produced.

2. The equations given by Professor Rowland to express the propagation of twisted plane polarized light are not suitable for that purpose, for they in fact express the propagation of a uniformly and continuously rotated plane polarized ray, such as is at present unknown to experimental physics.

3. The velocity of a twisted plane polarized ray is so related to the velocities of the right and left circularly polarized rays of which it is composed that its reciprocal is the arithmetical means of the reciprocals of its components; and the velocity of Professor Rowland's rotating plane ray is the arithmetical mean of the velocities of its right and left circularly polarized components.

4. The differential equation based on two different electromagnetic hypotheses as to the action of the medium in producing rotation or twisting of plane polarized light in a magnetic field involves an equation expressing the relation of the velocity of this kind of light at zero field to its velocity in the given field. On the hypothesis of orbital motions of charged ions the differential equations show that the field would cause a decrease in the velocity of plane polarized light during the twisting; while on the hypothesis of charged ions having a motion of translation across the field, the differential equations show that the field would cause an increase in the velocity by an amount one-third as great as the decrease just mentioned. This increase or decrease is of the second order of small quantities, and is so minute as to be at present beyond the range of observation, varying as it does as the square of the observed change produced by the field in the velocity of circularly polarized rays.

5. MacCulloch's differential equations involve practically the same decrease of velocity by the medium as those based on orbital motions of charged ions.

6. A moderate amount of absorption in the medium would not practically modify the conclusions true for perfectly transparent media on either hypothesis.

On the Theory of Experiments to Detect Aberration of the Second Degree. EDWARD W. MORLEY, Western Reserve University, and DAYTON C. MILLER, Case School of Applied Science. (To be published in the *Proceedings* of the American Academy of Science, and in the *Philosophical Magazine.*)

In this paper there is a reconsideration of the simple theory of aberration of the second degree as given by Michelson and Morley in 1887, and of the general theory as given by Hicks. The effects due to aberration of the first, second and higher degrees have been computed, and the results are shown in curves. The conclusion is that the original theory was correct and sufficient, and that the modifications proposed by Hicks are effective in aberration of the third or fourth degree only, or are (in two instances) due to errors in his theory.

Report of an Experiment to Detect Change of Dimension of Matter Produced by its Drift through the Ether. EDWARD W. MORLEY and DAYTON C. MILLER. (To be published in the *Proceedings* of the American Academy of Science, and in the *Philosophical Magazine.*)

The paper describes a large interferometer designed for the measurement of ether drift, and for the determination of any differential change in the dimension of matter, resulting from such a drift. The support of the optical parts is a steel truss-pattern cross, which is circumscribed by a square with diagonals fourteen feet long. By repeated reflections the optical path of the light is lengthened to two hundred and eleven feet. The whole interferometer is floated on mercury to render observations possible in all azimuths. The distances apart of the mirrors are determined by interchangeable rods, which may be of any suitable material. Experiments have been made using pine distance pieces, which give results in accordance with those of the original experiment made by Michelson and Morley in 1887 in which the distances were determined by sandstone.

The theory given in the preceding paper indicates a displacement of the interference fringes due to ether drift amounting to 1.53 wave-lengths, as the apparatus is rotated. The observations from 260 rotations show that the displacement is less than 0.015 wave-length. As the latter quantity is as small as the errors of observation, the conclusion is that there is no drift of the ether at the place where the interferometer is mounted.

Recent Experiments and Theories on the Ether Drift. D. B. BRACE, University of Nebraska.

The Elimination of Gas Action in Experiments on Light Pressure. G. F. HULL, Dartmouth College. (To be published in the *Philosophical Magazine* and in the *Physical Review.*)

When light is thrown on one vane of a torsion system suspended in a partial vacuum, the 'Crookes effect' or gas action is eliminated, leaving only light pressure effective, in the following ways: (1) By making the vane accurately vertical; (2) by *enclosing* the absorbing or reflecting surface; (3) by making the vane a cylindrical surface having its axis coincident with the suspending fiber; (4) by using inclined surfaces and polarized light.

Experiments are described and data given showing that the gas action is eliminated through large ranges of air pressure varying from about half an atmosphere up to a few millimeters of mercury.

A simple lecture room experiment is described for demonstrating that light pressure on a reflecting surface is greater than that on an absorbing surface in the ratio

of $1 + r_1 : 1 + r_2$, where r_1 and r_2 are the reflection coefficients of the two surfaces.

The Distribution of Energy in the Visible Spectrum. EDWARD L. NICHOLS, Cornell University. (To be published in the *Physical Review.*)

This paper gives definite numerical and graphical data for the variation of intensity with wave-length in the visible spectrum of various sources of light such as the Hefner lamp, the ordinary gas flame, the petroleum flame, the acetylene flame, the Nernst filament, the lime light, the magnesium light and the carbon arc light; also in the spectrum of incandescent bodies such as carbon, platinum and zinc oxide at known temperatures.

Hitherto our knowledge of these spectra has been relative, each being compared with some other taken as a reference standard. It is now possible, however, to reduce all spectrophotometric comparisons to absolute measure.

A Note on Interference with the Bi-Prism. WM. MCCLELLAN, University of Pennsylvania.

The condition that diffraction and interference lines obtained by means of the biprism shall be seen separately, depends on the relative positions of the screen prism and slit, and the angle of the prism. The writer has taken several photographs to illustrate the various fields which may be obtained from the same prism.

The Evolution of Hydrogen from the Cathode in Gases and its Association with Cathode Rays. CLARENCE A. SKINNER, University of Nebraska.

Exhibit of Liquid Air Machine in Operation. ARTHUR W. GOODSPEED, University of Pennsylvania.

DAYTON C. MILLER,
Secretary of Section B.

THE CONVENTION OF THE ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

THE eighteenth annual convention of this association was held in the Chamberlain Hotel, at Des Moines, Iowa, November 1–3. It was the first meeting under the new constitution, which reduces the number of sections from five to two; and the advantage of the new plan was very marked in enabling delegates to follow the discussions more closely, and in concentrating the deliberations upon questions of administration and methods of work. The two sections under the present constitution are (1) on college work and administration, and (2) experiment station work.

The general sessions were presided over by Dr. W. O. Thompson, of the University of Ohio, who delivered the customary presidential address. This dealt with 'Some Problems in the Colleges of Agriculture and Mechanic Arts,' and gave special attention to the agricultural phase of their work. Among the problems noted were the conditions in the agricultural communities, the much-discussed tendency away from the farm, and the frequent lack of opportunity on the part of the farmer's boy for individual initiative. It was urged that farm life must not be the refuge of necessity, that not all farmers' sons are suited to be farmers any more than all lawyers' sons are suited to that profession, and that marked changes in farming have taken place in recent years which call for special aptitude and training quite as much as any other work in life. It was pointed out that intelligent operation of the farm is now necessary for any margin of profit, and the fallacy that unintelligent men can make successful farmers or satisfactory farm laborers was denounced. 'We need to know that intelligence on the farm will produce results just as surely as elsewhere,'